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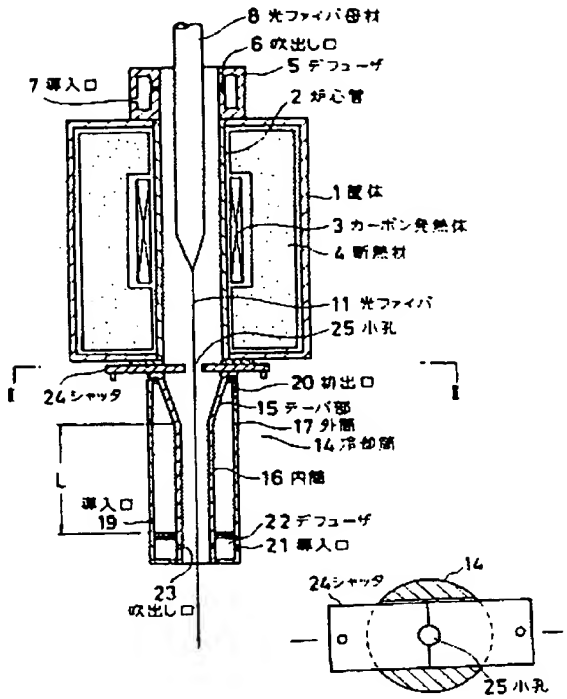
TITLE : DRAWING FURNACE FOR OPTICAL FIBER



ABSTRACT : PURPOSE: To produce an optical fiber having high quality with less fluctuation in the outside diameter thereof by providing a furnace core tube, heater, cooling cylinder and shutter and combining the same in a manner as to make specific effect.

CONSTITUTION: A drawing furnace is provided with the cylindrical furnace core tube 2 made of a heat resistant stock in the central part of a housing 1 made of a metal. The central part of the furnace core tube 2 is enclosed by a carbon heating element 3 and is kept at a high temp. An insulating material 4 is filled in the housing 1 enclosing the tube 2 and the element 3. A toric diffuser 5 concentrical with the tube 2 is connected to the top end of the tube 2 so that an inert gas introduced from an introducing port 7 thereof is blown slightly downward from a blow port 6. The cooling cylinder 14 which is concentrical with the tube 2 and is cooled by a cooling medium such as water is connected via the shutter 24 having a small hole to allow the passage of an optical fiber 11 to the bottom end of the tube 2. A cooling water inflow port 19 and outlet 20 are provided to the outside cylinder 17 of the cooling cylinder 14 to cool the cylinder 14 to a prescribed temp.

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(54) Optical fiber drawing furnace

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[There are no amendments to the text of the application.]

Specification

1. Title of the invention

Optical fiber drawing furnace

2. Claims

1. Optical fiber drawing furnace, characterized by comprising a furnace core tube, through which an optical fiber base material is inserted and an inert gas flows down, a heater that surrounds the furnace core tube and heats the optical fiber base material, a cooling tube that is installed contacting the lower end of the furnace core tube and that cools the inert gas by cooling medium fed to it, and a shutter that is installed between the cooling tube and the lower end of the furnace core tube and has a hole in the center for passing optical fiber through.

2. Optical fiber drawing furnace, characterized by comprising a furnace core tube, through which an optical fiber base material is inserted and an inert gas flows down, a heater that surrounds the furnace core tube and heats the optical fiber base material, a cooling tube that is installed contacting the lower end of the furnace core tube and that cools the inert gas by cooling medium fed to it, a shutter that is installed between the cooling tube and the lower end of the furnace core tube and has a hole in the center for passing optical fiber through, and a diffuser that is installed at the lower end of the cooling tube and that blows an inert gas into the cooling tube.

3. Detailed explanation of the invention

Industrial field of the application

The present invention concerns an optical fiber drawing furnace that can produce high-quality optical fibers and is excellent in durability.

Conventional technology

The cross-sectional structure of a conventional optical fiber drawing furnace is shown in Figure 3. The furnace contains cylindrical furnace core tube (2) made of a heat-resistant material such as graphite, etc. in the center of the body (1), and middle part of this furnace core tube (2) is wound with a carbon heater (3). The space between the outer area of the furnace core tube (2) and carbon heater (3) and inside of the body (1) is packed with thermal insulator (4). The optical fiber base material (8) is inserted into the furnace core tube (2) from the top, melted by the carbon heater (3) at the middle of the furnace core tube (2), and the carbon fiber (11) is drawn and discharged from the furnace from the bottom of the furnace core tube (2). At the upper end of the furnace core tube (2), circular upper diffuser (5) concentric with the furnace core tube (2) is installed, and an inert gas is introduced through

the inlet (7). A number of blow outlets (6) that blow an inert gas somewhat downward to the outer surface of the optical fiber base material (8) that is inserted along the inner wall of the upper diffuser (5) are installed on the inner wall of the upper diffuser (5). The inert gas blown out of the blow outlet (6) flows down surrounding the optical fiber base material (8) in the furnace core tube (2) and is discharged out of the tube from the outlet (13) at the lower end of the furnace core tube (2), and at the same time a portion is discharged upward along the outer surface of the optical fiber base material (8), thus the outer atmosphere is prevented from flowing into the furnace core tube (2).

Also, at the outlet (13) at the lower end of the furnace core tube (2), circular lower diffuser (9) concentric to the furnace core tube (2) is installed. An inert gas is led from outside into the lower diffuser (9), and a number of nozzles (10) open on the inner wall of the lower diffuser (9) are installed. Through the nozzles (10), an inert gas is blown downward to the optical fiber (11), for prevention of outside atmosphere from entering into the furnace core tube (2). A portion of the inert gas blown from nozzle (10) flows upward in the furnace core tube (2).

As described above, the optical fiber base material (8) is fed straight down into the furnace core tube (2) heated to a high temperature, e.g., 2100°C, by a feeding mechanism which is not shown, and the optical fiber (11) formed is wound by a winder which is not shown.

Problems to be solved by the invention

Of the required performances of optical fiber drawing furnace, stable outer diameter of optical fiber (11), extreme cleanliness inside the furnace, filling the furnace interior with an inert gas to prevent wear by penetration of oxygen in the atmosphere, etc., are important.

In the conventional optical fiber drawing furnace shown in Figure 3, the lower diffuser (9) is positioned at the lower end of the furnace core tube (2); thus a portion of the low-temperature inert gas blown from the lower diffuser (9) rises in the furnace core tube (2) at high temperature and mixes vigorously with the inert gas that is blown down from the upper diffuser (5) and becomes hot in the furnace, resulting in substantial turbulent flow.

On the other hand, the optical fiber (11) drawn down from the molten front end (12) of the optical fiber base material (8) fed into the furnace core tube (2) stays as molten soft state in a small region, then is immediately cooled and solidified to form an optical fiber (11) with final outer diameter and discharged from the furnace core tube (2). In this case, at the molten soft part of optical fiber (11) during the cooling and solidification of the optical fiber (11) from the molten front end (12) of the optical fiber base material (8), the above-described turbulent flow is formed by vigorous mixing of the hot inert gas blown down from the top and the cool inert gas blown up from the bottom, and the temperature fluctuation caused by such

turbulent flow may cause the outer diameter variation in forming the final outer diameter of the optical fiber (11). Also, near the outlet (13) of the lower diffuser (9), temperature rises because of the hot inert gas blown down from the top and at this portion, the cooled atmosphere flows into the tube. Such atmosphere flown in becomes rising flow in the furnace core tube (2), and this wears the furnace core tube (2) interior severely and also this reaction product adheres to the optical fiber (11), resulting in lowering of the strength of the optical fiber (11).

The present invention is to overcome such various drawbacks of the conventional optical fiber drawing furnace, and it is an object of the present invention to provide an optical fiber drawing furnace for the manufacture of optical fibers excellent in qualities with no penetration of atmosphere into the furnace.

Means for solving the problems

The optical fiber drawing furnace of the first invention is characterized by comprising a furnace core tube, through which an optical fiber base material is inserted and an inert gas flows down, a heater that surrounds the furnace core tube and heats the optical fiber base material, a cooling tube that is installed contacting the lower end of the furnace core tube and that cools the inert gas by cooling medium fed to it, and a two-piece shutter that is installed between the cooling tube and the lower end of the furnace core tube and has a hole in the center for passing optical fiber through. The optical fiber drawing furnace of the second invention is characterized by comprising, in addition to the constitution of the first invention, a diffuser that is installed at the lower end of the cooling tube and that blows an inert gas into the cooling tube.

Function

The optical fiber drawn from the lower end of the optical fiber base material fed from the upper end of the furnace core tube is surrounded by the inert gas fed from the top, and this inert gas is heated to a high temperature in the furnace core tube and then cooled in the cooling cylinder in such a way that at the lower end, its temperature is about same as ambient temperature, thus the atmosphere does not flow into the furnace core tube from the lower end of the cooling cylinder. Heating of the cooling cylinder by the radiative heat from the high temperature portion of the furnace core tube is suppressed by the shutter between the lower end of the furnace core tube and cooling cylinder, resulting in an enhanced cooling effect of the cooling cylinder.

Practical example

Figure 1 shows the cross-sectional structure of an example of optical fiber drawing furnace of the present invention, and Figure 2 shows the cross-sectional shape along the line II-II. The drawing furnace contains a cylindrical furnace core tube (2) made of heat-resistant material such as graphite, etc. in the middle of the body (1), and the middle part of the furnace core tube (2) is kept at high temperature by surrounding with a carbon heater (3). The interior of the body (1) containing the furnace core tube (2) and carbon heater (3) is filled with a thermal insulator (4). The upper end of the furnace core tube (2) is connected to a circular diffuser (5) concentric to the furnace core tube (2), and the inert gas introduced via the inlet (7) is blown somewhat downward through the blow outlet (6). The lower end of the furnace core tube (2) is connected to a cooling cylinder (14) that is concentric to the furnace core tube (2) and cooled by a cooling medium such as water, via a shutter (24) having a small hole through which the optical fiber (11) passes. Cooling water inlet (19) and outlet (20) are installed on the outer surface (17) of the cooling cylinder (14) for cooling the cooling cylinder (14) to a desired temperature. The upper end of tapered part (15) formed in the upper inner surface of the cooling cylinder has about the same inner diameter as the furnace core tube (2); it tapers gradually, connecting to the inner cylinder (16) of length L needed for cooling the hot inert gas flowing down the furnace core tube (2) to a desired temperature, e.g., about 100°C. The inner diameter of this inner cylinder (16) is tapered down from an inner diameter about the same as the inner diameter of the furnace core tube (2); thus the turbulence of the inert gas flow is prevented, and cooling efficiency of the inert gas is enhanced. At the lower end of the cooling cylinder (14), a diffuser (22) of the inert gas surrounding the inner cylinder (16) is installed integrally, and the inert gas introduced via the inlet (21) formed at the this diffuser (22) is blown out toward the center of the inner cylinder (16) from a number of blow outlets (23) installed around the inner cylinder (16).

An optical fiber base material (8) is introduced concentrically from the upper end of the furnace core tube (2), and the optical fiber base material (8) is melted at the high temperature part by the carbon heater (3) at the middle of the furnace core tube (2) and drawn at a certain speed to form an optical fiber (11) of desired outer diameter. The optical fiber (11) passes through the cooling cylinder (14) and is taken out from the lower end of the cooling cylinder (14). At this time, inert gas is fed downward from the blow outlet (6) of the diffuser (5) installed at the upper end of the furnace core tube (2). As a result, penetration of atmosphere into the furnace core tube (2) via the gap between the optical fiber base material (8) and the diffuser (5) is prevented, and also the optical fiber base material (8) is surrounded

by the down flow of the inert gas, thus the furnace core tube (2) is protected from oxidation. The inert gas fed into the furnace core tube (2) is heated at the high temperature part of the furnace core tube (2) and is then cooled as it descends through the inner cylinder (16) from the tapered part (15) of the cooling cylinder (14) connected to the lower end of the furnace core tube (2) to a desired temperature and discharged outside from the lower end of the cooling cylinder (14). The temperature of the inert gas discharged from the lower end of the cooling cylinder (14) is reduced to about ambient temperature by the cooling cylinder (14). As a result, there will be no thermal convection caused by temperature differences at the lower end of the cooling cylinder (14), and there will be no penetration of the atmosphere into the cooling cylinder (14) at all. Also, by the diffuser (22) of the inert gas at the lower end of the cooling cylinder (14), the inert gas is blown from the blow opening (23) open surrounding the inner surface (16) of this diffuser (22), and as a result, the penetration of air from the lower end of the cooling cylinder (14) is completely prevented. By installing a shutter (24) shown in Figure 2 between the furnace core tube (2) and cooling cylinder (14), the radiative heat from the high temperature part of the furnace core tube (2) is shielded, and the cooling efficiency of the inert gas at the cooling cylinder (14) is enhanced. The inner diameter of the small hole (25) formed in the shutter (24) is, e.g., about 5 mm, enough for dropping the chips during initiation of the drawing (by heat) of optical fiber (11). In Figure 2, the hole can be adjusted by sliding in the horizontal direction.

Experimental example

The apparatus shown in Figure 1 and 2 was used with the effective cooling length L of the cooling cylinder (14) being 50 cm, the cooling cylinder (14) inner diameter 2 cm, 3-mm-thick steel tube for the inner cylinder (16) of the cooling cylinder (14), cooling water at 20°C in the cooling cylinder (14), small hole (25) with a diameter of 5 mm of the shutter (24), no diffuser (22) at the lower end of the cooling cylinder (14), the flow rate of the inert gas flowing down from the furnace core tube (2) to the cooling cylinder (14) being 5 L/min. At a temperature of about 1000°C, the gas discharged from the lower end of the cooling cylinder (14) was 120°C. The oxygen concentration near the lower end of the furnace core tube (2) was 100 ppm, compared with 300 ppm in a conventional case without installation of the cooling cylinder (14), indicating a marked improvement. The outer diameter variance of the optical fiber (11) formed was ± 0.5 μm.

On the other hand, when the diffuser (22) was installed on the cooling cylinder (14), nitrogen gas was blown at a rate of 5 L/min from the diffuser (22). Under the same conditions as above, the oxygen concentration at the lower end of the furnace core tube (2) was reduced to 50 ppm. The outer diameter variation of the optical fiber formed was ± 0.5

μm, indicating the effect of the inert gas blowing on the outer diameter of the optical fiber (11).

The service life of the parts inside the furnace was about 2 weeks in the present invention, compared with about 1 week in conventional case.

Effect of the invention

According to the optical fiber drawing furnace of the present invention, by installing a cooling cylinder surrounding the optical fiber at the lower end of the drawing furnace, the temperature of the inert gas discharged into the atmosphere from the lower end of the cooling cylinder is low, thus the amount of air flowing in is extremely small, due to the temperature difference between the interior and exterior of the cooling cylinder, resulting in a marked extension of the service life of the furnace core tube. Also, there is no temperature variation caused by turbulence of the inert gas flow inside the furnace core tube, resulting in stabilization of the inert gas flow; thus an optical fiber with a uniform outer diameter and excellent qualities can be manufactured. By installing a diffuser at the lower end of the cooling cylinder, the penetration of air into the cooling cylinder is further completely prevented, resulting in further reduced wear of the parts inside the furnace core tube. Yet, by installing a shutter between the drawing furnace and cooling cylinder, the cooling efficiency of the inert gas flowing down the cooling cylinder can be enhanced further.

4. Brief explanation of the drawing

Figure 1 is a cross-sectional diagram of an example of optical fiber drawing furnace according to the present invention. Figure 2 is a cross-sectional diagram along the line II-II of Figure 1. Figure 3 is a cross-sectional diagram of a conventional optical fiber drawing furnace.

1 Body
2 Furnace core tube
3 Carbon heater
4 Thermal insulator
5, 22 Diffusers
6 Blow outlet
7, 19, 21 Inlets
8 Optical fiber base material
11 Optical fiber
14 Cooling cylinder

15 Tapered part
16 Inner cylinder
17 Outer cylinder
20, 23 Discharge outlets
24 Shutter
25 Small hole

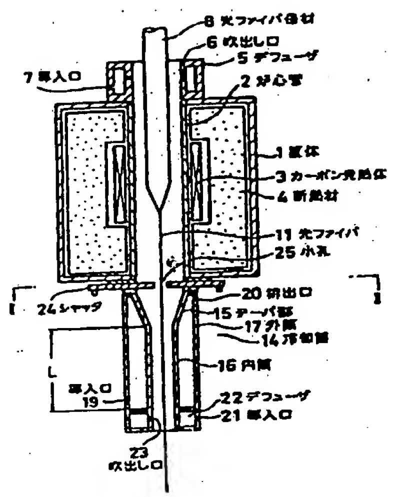

Figure 1

Key:
1 Body
2 Furnace core tube
3 Carbon heater
4 Thermal insulator
5, 22 Diffusers
6 Blow outlet
7, 19, 21 Inlets
8 Optical fiber base material
11 Optical fiber
14 Cooling cylinder
15 Tapered part
16 Inner cylinder
17 Outer cylinder
20, 23 Discharge outlets
24 Shutter
25 Small hole

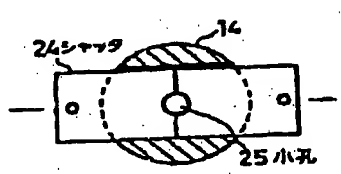

Figure 2

⑲日本国特許庁（JP）　　⑪特許出願公開

⑫公開特許公報（A）　　昭62-246837

⑤Int.Cl.4　　識別記号　　庁内整理番号　　㊸公開　昭和62年(1987)10月28日

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審査請求　未請求　発明の数　2　（全5頁）

㊹発明の名称　光ファイバ用線引き炉

㉑特　願　昭61-90077
㉒出　願　昭61(1986)4月21日

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明細書

1. 発明の名称

光ファイバ用線引き炉

2. 特許請求の範囲

(1) 光ファイバ母材が挿入されるとともに不活性ガスが流下する炉心管と、この炉心管を取り囲み且つ前記光ファイバ母材を加熱するヒータと、前記炉心管の下端に接続して設けられ且つ冷却媒体が供給されて上記不活性ガスを冷却する冷却筒と、この冷却筒と前記炉心管の下端との間に介装され且つ中央部に光ファイバを貫通させる小孔を有するシャッタとを具えたことを特徴とする光ファイバ用線引き炉。

(2) 光ファイバ母材が挿入されるとともに不活性ガスが流下する炉心管と、この炉心管を取り囲み且つ前記光ファイバ母材を加熱するヒータと、前記炉心管の下端に接続して設けられ且つ冷却媒体が供給されて上記不活性ガスを冷却する冷却筒と、この冷却筒と前記炉心管との間に介装され且つ中央部に光ファイバを貫通させる小孔を有するシャッタと、前記冷却筒の下端部に設けられ且つ不活性ガスを冷却筒内に吹き込むデフューザとを具えたことを特徴とする光ファイバ用線引き炉。

3. 発明の詳細な説明

＜産業上の利用分野＞

本発明は、外径変動の少ない高品質の光ファイバを製造し得る耐久性に優れた光ファイバ用線引き炉に関する。

＜従来の技術＞

従来の光ファイバ用線引き炉の一例の断面構造を表す第3図に示すように、この線引き炉は金属製の筐体1の中心部にグラファイト等の耐熱素材で作られた円筒状の炉心管2を備え、この炉心管2の中央部はカーボン発熱体3で取り囲まれていて、炉心管2及びカーボン発熱体3の外周と筐体1の内側との間の空隙には断熱材4が充填されている。尚、光ファイバ母材8は炉心管2の上端から挿入さ

性ガスを冷却する冷却筒と、この冷却筒と前記炉心管の下端との間に介装され且つ中央部に光ファイバを貫通させる小孔を有する二分割構造のシャッタとを具えたことを特徴とするものである。又、第2番目の本発明による光ファイバ用線引き炉は、第1番目の発明の構成に加えて、前記冷却筒の下端部に設けられ且つ不活性ガスを冷却筒内に吹き込むデフューザとを具えたことを特徴とするものである。

<作　　用>

炉心管の上端より供給された光ファイバ母材の下端から線引きされる光ファイバは、上方より供給される不活性ガスに囲まれ、この不活性ガスは、炉心管の中で高温に加熱されるが、冷却筒で冷却されてその下端では大気温度との温度差がほとんどなくなるため、冷却筒下端から炉心管への大気の流入が起こらない。また、炉心管下端と冷却筒との間のシャッタによって、炉心管高温部からの輻射熱による冷却筒の加熱が抑止され、冷却筒の冷却効果が更に高まる。

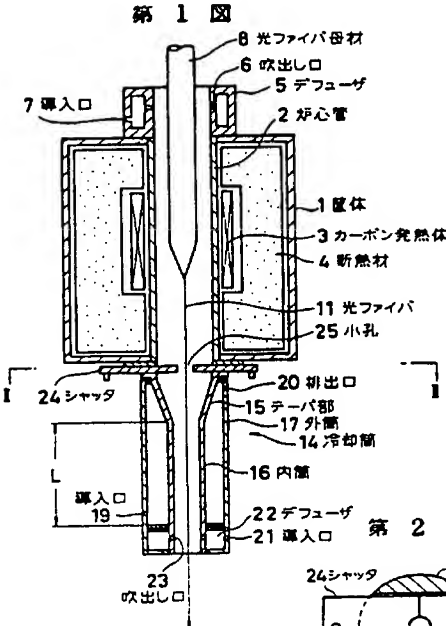
<実　施　例>

本発明による光ファイバ用線引き炉の一実施例の断面構造を表す第1図及びそのⅡ－Ⅱ矢視断面形状を表す第2図に示すように、線引き炉は金属製の筐体1の中心部にグラファイト等の耐熱素材で作られた円筒状の炉心管2を備え、炉心管2の中央部はカーボン発熱体3で取囲まれていて高温に保たれる。炉心管2及びカーボン発熱体3を取りまく筐体1の内側には断熱材4が充填されている。また、炉心管2の上端にはこの炉心管2と同心をなす円環状デフューザ5が連結され、その導入口7から導入される不活性ガスを吹出口6からやや下向きに吹き出すようになっている。また炉心管2の下端には光ファイバ11が通過し得る小孔を有するシャッタ24を介して炉心管2と同心状をなし且つ水等の冷却媒体水で冷却された冷却筒14が連結されている。

冷却筒14の外筒17には冷却水流入口19及び出口20が設けられ、冷却筒14を所定の温度に冷却している。また、冷却管筒の上部内周面に形成されたテーパ部15はその上端が炉心管2の内径とほぼ等しく、下側ほど次第に縮径されており、炉心管2を流下する高温度の不活性ガスが所望の温度例えば100℃位まで冷却するに必要な長さLの内筒16へと繋がっている。この内筒16の内径は炉心管2の内径とほぼ等しい内径からテーパ状に細くしてあることによって、不活性ガスの流れの乱れを防止するとともに不活性ガスの冷却効率を高めている。冷却筒14の下端には内筒16を囲む不活性ガスのデフューザ22が一体的に設けられており、このデフューザ22に形成された不活性ガス導入口21から導入された不活性ガスは、内筒16の周囲に設けられた複数個の吹出し口23から内筒16の中心に向けて吹き出すように構成されている。

線引き炉の炉心管2の上端よりこれと同心に光ファイバ母材8が導入され、炉心管2中央のカーボン加熱体3による高温部で光ファイバ母材8が加熱溶融され、所定の線引き速度で所定の外径の光ファイバ11に線引きされる。線引きされた光ファイバ11は冷却筒14を通過して冷却筒14の下端から外部へ引き出される。この際、炉心管2の上端に設けられたデフューザ5の吹出し口6から下向きに不活性ガスを供給し、光ファイバ母材8とデフューザ5との間隙を通って炉心管2内へ大気が侵入するのを防止するとともに光ファイバ母材8の周囲を不活性ガスの下降流で取り囲み、炉心管2の酸化に対して保護している。炉心管2内に供給された不活性ガスは炉心管2の高温部で高温になるが、炉心管2の下端に連結された冷却筒14のテーパ部15から内筒16を下降するに伴って冷却され、必要な温度まで下げられ、冷却筒14の下端から外部へ放出される。冷却筒14の下端か

第 1 図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6 吹出し口
5 デフューザ
7 導入口
2 炉心管
1 筐体
3 カーボン発熱体
4 断熱材
11 光ファイバ
25 小孔
20 排出口
I
I
24 シャッタ
15 テーパ部
17 外筒
14 冷却筒
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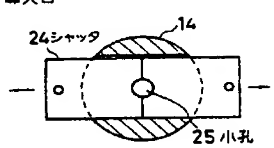
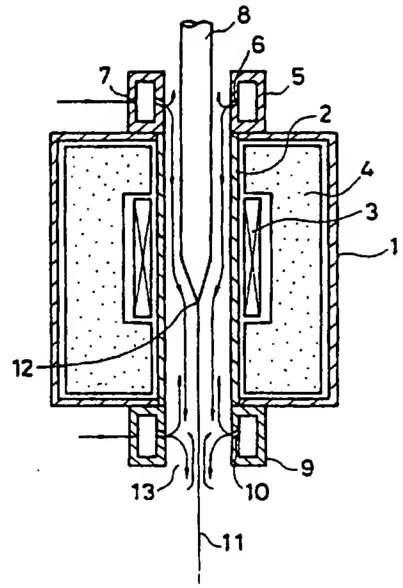
吹出し口

第 2 図


24シャッタ
14
25 小孔

第 3 図


8
6
7
5
2
4
3
1
12
9
13
10
11

Key: 24 Shutter
25 Small hole

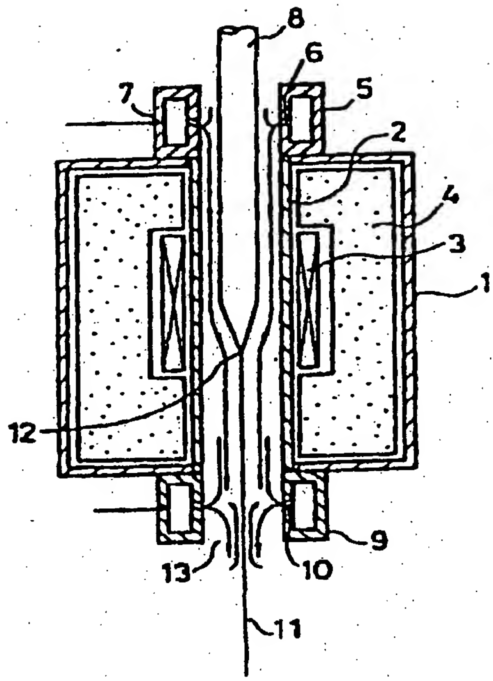


Figure 3